SYSTEM OF INDICATIONS OF METEOROLOGICAL RESEARCH EFFICIENCY

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16. Abstract

A number of factors, including indices of the value (scientific, applied, methodological), level of introduction (publication, materials and equipment, creative problem solving) and level of importance are considered to be the major factors to be considered in evaluating efficiency of scientific research. An analytical-parametric system for quantitative evaluation of efficiency of scientific research is presented. A series of criteria for assigning a numerical rating to each parameter and a set of weighting factors for each parameter are presented. The system is said to be applicable to all stages of research and development, from the stage of forecasting expected results of the work through final application of the development.

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ANNOTATION

The role of various factors determining the accomplishment of scientific research work is discussed. On the basis of a systematic analysis, an analytical-parametric scheme of indicators and standard base are proposed, permitting the quantitative evaluation of the efficiency of the scientific research work at all stages of conduct of the research.

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The transformation of science into a leading factor in acceleration /86* of the rates of development of the material and spiritual basis of a socialist society has raised the problem of a significant increase in its efficiency in a number of major State tasks, stated in the resolutions of the XXIV Congress of the Communist Party of the Soviet Union. Fulfillment of these tasks requires a radical improvement in existing ways of mobilization of the internal reserves of science and searching for fundamentally new ways.

A detailed analysis of some important aspects of this problem, applicable to the tasks of the USSR Hydrometeorological Service, is contained in the work of Academician Ye. K. Fedorov [9]. Ye. K. Fedorov distinguishes the following as the primary factors in development of scientific research: 1. interrogation of experience; 2. the internal logic of development of science; 3. the personal scientific interests of investigators; 4. the physical resources for conducting the research (the make-up of the organization, the presence of equipment and the like). The first of the factors listed is considered to be the freest, and the remaining factors, conservative, retaining the resources at the "time of taking a direction."

Work [9] gives a basis for concluding that a way to improve Hydrometeorological Service research and development efficiency is to develop and use the available reserves of the conservative factors in growth of scientific research work indicated above, on the basis of improvement of the organizational structure of the scientific research process. In fact, the principal moving force of the nonmobile factors noted in development of this process are organizations of people, and the level of activity of the latter depends significantly on a multitude of external

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* Numbers in the margin indicate pagination in the foreign text.

and internal factors of scientific organization: financial, organizational, physical, energy, information and social-psychological. The most conservative among these factors are the financial, social-psychological and physical-technical, and the freest are the organizational factors. It is precisely the organizational factor which permits optimization of the coordinated action of all the remaining factors on the investigator and on the scientific research organization and, on this basis, in principle, indefinitely increasing their purposeful activity and, consequently, the productivity of scientific research work.

In solving problems of a complex nature in improvement of the organizational factor of science, an improvement in the methods and procedures of evaluating scientific activity and its results has an important role. Scientific work, like any other productive activity, is based on organization, adopting and executing diverse decisions and actions, and any decision is an act of choice of one of the existing possibilities and, therefore, it assumes an evaluation of these posibilities. Consequently, evaluations determine the course of the research process in the most direct manner and indirectly affect its results.

Continual attention is being paid to methods of evaluation of scientific work. From a history of many centuries of development of /87
science, a quite effective system of evaluating the individual work of scientists has been created and continually improved, in the form of various procedures and resolutions of scientific councils, seminars, competitions, reviews and the like. This system now operates in the majority of scientific institutions of the USSR Academy of Sciences, ministries and services, including the USSR Hydrometeorological Service.

However, it should be emphasized that significant shortcomings in this system, oriented on evaluation of predominantly individual forms of scientific work, are beginning to be noted more and more often in the scientific literature [4]. In fact, the scientific-technological

revolution has radically changed the face of modern science, transforming it into a directly productive force in society. Strengthening of the productive function of science is particularly clearly evident in the example of the expansion and qualitative deepening of the sphere of provision of meteorological information of the USSR Hydrometeorological Service in various branches of the national economy, the total economic value of which reached one billion rubles in 1972 [10]. The very nature of scientific activity is changing in a significant fashion; it now is characterized, not so much by the activity of gifted individuals and small groups of enthusiasts, typical of classical science, as by the joint work of scientific organizations, solving major problems of science and the national economy. The solution of each such problem, as a rule, involves the necessity of a multiple examination and accomplishment of specific complex sets of scientific, engineering-technical and administrative-economic tasks, each of which makes its significant contribution to the common solution.

Under these conditions, traditional methods of evaluating creative productivity of the individual work of a scientist can be considered to be only one part, although, as before, an extremely important, aspect of the activity of a modern scientific research organization. Therefore, evaluations of this activity, obtained on this basis, is proving to have a very limited regulating effect on the scientific research process of a modern scientific research institute, which is complex by its nature. Moreover, in connection with the steadily increasing function of science in the sphere of public works, the level of the overall requirements on the quality of control of the scientific research process is increasing steadily.

Thus, an urgent requirement is arising to supplement the existing system of evaluation of individual scientific work with specific methods of evaluating the collective forms of this work. The solution of this problem requires, in our opinion, a fundamental review of the very basis of the traditional system of evaluation, its basic concepts

and principles, and the incorporation of new concepts and principles into these bases which are capable of adequately reflecting the specifics of the collective forms of scientific work.

EFFICIENCY OF SCIENTIFIC RESEARCH WORK

In the general methodology of evaluation of individual form of scientific work, the principal initial concepts are the concepts of productivity, getting results, output and others characterizing various aspects of individual work. At the same time, for characterization of complicated forms of collective work, the concept of efficiency is being used more and more frequently in modern literature [4, 8].

The concept of efficiency, just like the concepts of output or productiveness, is characterized by the ratio of product (result) obtained in productive activity to production input and, consequently, it also expresses the ratio of output to input. However, the concepts of efficiency and productivity reflect output at different levels of social consumption of labor, respectively, at the collective and individual levels and, therefore, these concepts reflect fundamentally different levels of productive and social-economic ratios.

The concept of efficiency is used ambiguously in economics literature; its content changes significantly with use in productive or nonproductive spheres [8], which is connected with differences in the social products producible in them. The content of the concept of efficiency, with its use in the nonproductive sphere is not exhausted by a simple statistical ratio of the results of the work to inputs, as occurs in the productive sphere, but the completeness and efficiency of use of all the productive, social-economic, economic and other internal connections and relationships of a given enterprise or branch, its external connections and relationships with other branches of the national economy and spheres of public activity also are accounted for in it [8].

Modern science is, although very specific, a component part of the economic system of society. At the same time, of its aggregate output, only certain types of scientific results have a direct effect in terms of money, and the majority of them only have an indirect effect on the national economy.

For an evaluation of scientific results having a direct economic effect, a standard procedure is used at the present time [6], while, for evaluation of the efficiency of scientific results of a nonproductive nature, there is no similar procedure as yet.

EXPERT-ANALYTICAL METHOD OF EVALUATION OF EFFICIENCY OF SCIENTIFIC RESEARCH WORK

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For development of a method of evaluation of the efficiency of scientific results having, not a direct, but an indirect effect on the national economy, it is advisable to use the concept of efficiency in the nonproductive meaning pointed out above. In this case, the possibility appears of clearly formulating the basic requirements as to accounting for and measuring the characteristics (indices, parameters) of the labor input, scientific importance of the results of the work, the consumer value of the scientific results obtained, the internal structure of the organization and its external connections, and the principal forms of connections and relationships among the set of characteristics indicated.

In principle, satisfaction of these requirements is possible by three methods: a. analytical, b. expert and c. mixed (expert-analytical).

The principal virtue of the analytical method is the objective reliability of the estimates obtained by means of it. However, putting it to practical use still is impossible, because of the high requirements for theoretical and practical knowledge of the objects and subjects of the evaluation of scientific research organizations. The expert method of evaluation is devoid of this limitation; it is based on use of the synthetic knowledge of experts, determined by their high qualifications

and experience. However, specific deficiencies are inherent in the expert method of evaluation: first and foremost, the subjectivity introduced into the evaluations by experts and the requirements for the expert commission having a multiprofile qualification, flowing from the necessity of taking account of a multiplicity of different aspects of complicated, collective scientific research work.

The expert-analytical method is based on the idea of a compromise solution of the task of objective evaluation of collective forms of scientific work, on the basis of a partial matching of the advantages noted in the analytical and expert methods. The essence of the expert-analytical method is that the evaluation of collective forms of scientific work is accomplished by experts (specialists), within the frame of reference of some generalized analytical-parametric system of an object which can be evaluated, described in the essential outlines as a set of parameters (characteristics) of the object, as in the simplest analytically expressible connections among these parameters. An apriori analytical-parametric system of an organized object (scientific research groups, laboratories, sections, scientific research institutes and the like) and the independence of expert judgments (opinions), in this manner, are the basic factors in increasing the level of objectivity and logical depth of the evaluations, obtained on the basis of the expert-analytical method.

Some questions in development of this method will be discussed below, applicable to the solution of problems in evaluation of efficiency of collective forms of accomplishing scientific research of a meteorological nature. Since the basis of the method is the analytical-parametric system of an object which can be evaluated, the principal attention will be given to discussion of questions of selection and justification of elements of this system, in accordance with the general theoretical-methodological principles of its development, reported in work [7].

We have accomplished parametrization of the system, from the point of view of a systematic analysis [5] and cybernetics [11, 12], and the choice of a specific analytical relation between the parameters of the object being evaluated, from the point of view of economic cybernetics [2] and the management of science [1, 3].

ANALYTICAL-PARAMETRIC SYSTEM OF EVALUATION OF EFFICIENCY OF SCIENTIFIC RESEARCH WORK

The first version of the analytical-parametric system of evaluation of collective forms of scientific work, briefly described in [7], was distributed among 56 colleagues of the Central Aerological Observatory, section and laboratory heads, and supervisors and responsible performers of projects. It was requested that this category of colleagues express (at the level of independent expert evaluations), in a special questionnaire, their attitude toward the general idea of the systematic evaluation and toward the proposed classification of all research and development of the Central Aerological Observatory, and also to give their remarks about the proposed specific systems for evaluation of efficiency in accomplishment in scientific research subject areas, in each of these groups.

Analysis of the questionnaire material obtained showed that the majority of supervisors and responsible performers in subject areas had a positive attitude toward the very idea of evaluation of efficiency of scientific research work, towards the conduct of the appropriate technical-economic studies, and toward a selected systematic direction of these studies and to a differentiated approach to evaluation of efficiency of research and development of various types.

Systematization and analysis of the questionnaire material revealed some weak aspects and deficiencies in the first version of the analytical-parametric system of evaluation of efficiency of scientific research work and permitted planning specific ways to eliminate them.

Thus, on the basis of this analysis, the following three principles of evaluation of scientific, technical and methodical importance of the results of research and development were developed, namely: 1. by the maximum effects and application of results in scientific research subject areas; 2. by the maximum effect of a single result /89 or application of the result of scientific research work; 3. by the maximum convenience for users of these results -- supervisors, scientific, engineering technical workers and specialists of interested institutions and enterprises of the various ministries and services.

Finally, a simplified system of the base indicators of efficiency of collective forms of accomplishment in scientific research subject areas was developed in the following form:

$$E=f(I, Q, P, L, M, N, H, W, T\ U), \quad (1)$$

where E is the efficiency of the scientific research work; I is an index of the scientific value of the results of scientific research; Q is an index of the applied value of the result of scientific research work; P is an index of the methodical (organizational-economic) value of the results in the subject areas; L is an index of the level of introduction of information materials by subject area (publications, reports and the like); M is an index of the level of introduction of scientific-technical results by subject area (technical devices, units, blocks, instruments and the like); N is an index of the level of introduction of operational-methodical resources by subject area (method of forecasting weather, operational actions on the weather, operation of instrument sets; projects for organization of network bases, stations, expeditions and the like); H is an index of the level of the creative contribution of the subject matter performer in solution of the scientific, technical and methodical questions in the process of accomplishing work in the subject area ; W is an index of the level the contribution of the subject area

performer in equipping the experimental and field test bases in the process of working out the subject; T is an index of the level of forecasting of expected results, planning, organization, supervision and monitoring at all stages of accomplishment in the subject area; and U is an index of the level of importance of the subject area, which is, in its way, a measure of the responsibility of the organized group of performers in the subject area for the quality of its results, efficiency and accomplishment and introduction of results into practice.

For development of the specific analytical characteristics (functions) of equation (1), a knowledge is required of the general quantitative principles of structure and function of the organization object proper, in our case, the organized group of performers in scientific research subject areas. Since modern organization theory still does not provide this type of knowledge, being in its formative stage, one has to be limited to a different type of approximation. In particular, the assumption of the independent nature of each of the sets of parameters of an economic object under consideration is used in economics-mathematical literature [2]. This permits use of linear relationships among these parameters. Considering the parameters of the right side of equation (1) to be independent of one another, and introducing a quantitative range scale (for example, in points) for each of them, an approximate analytical expression for function (1) can be established. For this purpose, in particular, the method of summation of the rating points over all indices of efficiency can be used [2]:

$$R_{\Sigma} = \sum_{i}^{n} \eta_i \cdot K_i, \qquad (2)$$

where R_{Σ} is the total point rating of efficiency of accomplishment in a scientific research subject area; n is the number of parameters (indices) of the analytical-parametric system; η_i is the weight factor (significance) of the i-th index; K_i is the expert quantitative evaluation (in points) of the i-th index.

Expression (2) characterizes the simplest (linear) type of analytical-parametric system of evaluation of efficiency of collective work of performers in a scientific research subject area. In this system, the relation between R_Σ and the i-th index (parameter) of collective scientific work is of a linear nature, while the quantitative values of the weight factor η_i of this index may change nonlinearly.

Thus, the system of evaluation of efficiency of collective scientific work by equation (2) is based, as though on a "double" parametrization of the object being evaluated, namely, by independent parameters (1) and by the nonlinearly changing weight ("target") parameter η_i, characterizing the significance of a given value of K_i in scientific and national economic output in a scientific research subject area.

STANDARD PARAMETRIZATION BASE

For an expert determination of the quantitative values of (1) and system (2), parametric standard scales (Table 1) and weight factors (Table 2) were developed. We used Tables 1 and 2 for determination of efficiency in a subject area only in the final stages of accomplishing /92
it. Although such a quantitative evaluation can be accomplished (by means of monitoring and self-monitoring) at all stages of research, beginning with the stage of forecasting expected results, planning work in the subject area and ending with the final stage of scientific research work.

In development of a standards base for a quantitative estimate of the values of the indices (1), for determination of the number factors K_i of equation (2) and the weight factors η_i corresponding to these factors, the greatest difficulty arose in plotting tables of the weight functions, since the coefficients η_i should ultimately characterize the specific value of the integral output of various scientific parameters in increasing the efficiency of public industry and economics.

The starting point for plotting Table 2 was a prognostic estimate of that potentially expected contribution of scientific research work to

TABLE 1

STANDARD TABLE OF INDICES OF EFFICIENCY AND ACCOMPLISHMENT IN THE SCIENTIFIC RESEARCH SUBJECT AREAS

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Indices: Types	Index	Characteristics of index and its qualitative range				
Effectiveness of results obtained	I	The results in the subject area make the following contribution to study of structure and properties of the atmosphere and elements of it (directed towards expanding or deepening the experimental material, determination or refinement of empirical relations, planning or development of descriptive, design or calculating theory and the like)				
		Refine previously know facts negligibly	Demonstrate lack of promise or confirm promise of existing scientific direction	Systematize and correlates material in a given scientific area	Significantly supplement and refine scientific areas	Fundamentally change existing or discover new scientific areas (scientific discovery)
	Q	Results in the subject area make the following contribution to working out and development of experimental base for study of the atmosphere (directed toward increasing accuracy, reliability and complexity of measurements, automation of processing of large amounts of data and the like).				
		Negligibly improve existing method, apparatus	Demonstrate promise or lack of promise of existing method, apparatus	Modernize existing method, apparatus	Propose new method, apparatus	Propose fundamentally new method, apparatus (Patent, license)
	P	Results in subject area make the following contribution to increase in productivity of labor in scientific research and industrial practice (directed towards improvement of operating characteristics, increasing processing standards and operational importance of meteorological data obtained)				
		Negligibly improve standard, conditions of organization and operational techniques, etc.	Demonstrate promise or lack of promise of existing conditions of organization, operating techniques, processing standards and the like	Modernize existing conditions of organization, operating techniques, increase processing standards, etc.	Propose new conditions for organization and operating techniques, new processing standards and the like	Propose fundamentally new conditions of organization and operating techniques, processing standards, etc.

TABLE 1 (continued)

Indices: Types	Index	Characteristics of index and its qualitative range				
Efficiency of introduction of results obtained	Z	Results in subject area are introduced and are used (directed toward acceleration of rates of scientific-technical and economic progress) at scales and on the levels:				
	M N	Section, laboratory	Scientific Research Institute	Main Administration of the Hydrometeorological Service (branches)	National economy	On a world-wide scale
Efficiency of process of accomplishment in subject area	H	In the process of accomplishment in subject area, scientific, engineering-technical and methodological problems have been solved creatively (new methods of calculation, hypotheses, concepts, theories, technology and the like) to the extent of				/91
		Narrow theoretical or experimental questions in a given scientific area	A broad group of theoretical, experimental or methodological questions in a given area	A set of theoretical, experimental and methodological questions in a given area	Narrow theoretical, experimental or methodological questions in a new area	An extensive set of theoretical, experimental and methodological questions in a new scientific area
	W	In the process of accomplishment in the subject area, created an experimental base (laboratory installations, technical equipment of an expedition, equipment of an aircraft laboratory, the scientific research station factory machine testing station and the like), to the extent of:				
		Laboratory model	Laboratory set of apparatus, including models and industrial products	Expeditionary set of apparatus, based on laboratory models and manufactured products	Partially automated field set of apparatus and equipment	Completely automated field set of apparatus and equipment
	T	In the process of accomplishment in subject area, used a multiple system of forecasting, planning, organization, control and monitoring of scientific research work, a major repair department providing coordinated deliveries of equipment, replenishment parts, expendable materials, technical documentation and the like, with an extent of interrelations and interactions between:				

TABLE 1 (continued)

Indices: Types	Index	Characteristics of index and its qualitative range				
	T (cont'd)	Auxiliary subdivision and services of a scientific research institute	Scientific and auxiliary subdivisions and services of a scientific research institute	Allied organizations of Main Administration of the Hydrometeorological Service	Allied organizations of different services	Allied organizations of different services and international organizations
Importance of subject area	U	Accomplishment in subject area was accompanied by requirements and responsibilities (for quality of results, operational importance of their introduction, absence of interruptions in time and supplies and the like), at the level of a plan, program, project:				
		Section, laboratory	Scientific Research Institute	Main Administration of the Hydrometeorological Service (branches)	Interservice, national economy	International
Quantitative range of values (in points)		1-2	3-4	5-6	7-8	9-10

TABLE 2
WEIGHT FACTORS η_i FOR INDICES OF EFFICIENCY IN ACCOMPLISHMENT IN SCIENTIFIC RESEARCH SUBJECT AREA

Indicators (index)	Rating in points				
	1—2	3—4	5—6	7—8	9—10
I	1	1.2	1.7	2.7	5
Q	1	1,1	1,4	1.9	3
P	1	1	1,2	1.5	2
L	1	1,3	2	3	4
M	1	1,3	2	3	4
N	1	1,3	2	3	4
H	1	1.1	1,5	2,2	3
W	1	1,1	1.5	2,2	3
T	1	1,3	2	3	4
U	1	1.3	2	3	4

growth of scientific-technical and economic progress (on the national or world scale), which directly or indirectly is reflected by the system of indices (1). In this system, the direct contribution of scientific research work to growth of scientific-technical and economic progress is reflected by indices I, Q and P, and this influence is reflected only indirectly by the remaining indices.

The optimum growth in scientific-tenchical and economic process under modern conditions is accomplished [1] according to the following principle:

$$\frac{dS}{dt} > \frac{dF}{dt} > \frac{d\Pi}{dt}, \qquad (3)$$

where dS/dt, dF/dt and d Π/dt are the rates of growth of science, technology and industry, respectively. In accordance with this principle,

high rates of growth of modern industry and economics should correspond to still higher rates of growth in new technology, and the latter, in turn, should be anticipated by the rates of growth in science (Fig. 1). Based on this principle, it can be considered that

$$\eta(I) \geq \eta(Q) \geq \eta(P). \qquad (4)$$

where $\eta(I)$, $\eta(Q)$ and $\eta(P)$ are the weight factors for the indices of efficiency of scientific research work I, Q and P respectively.

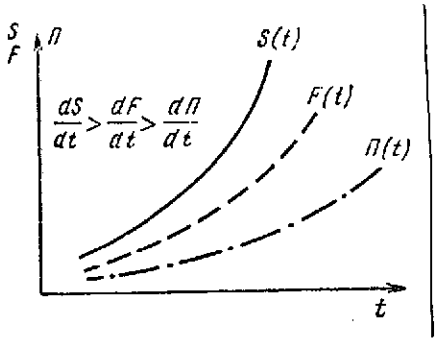

Fig. 1. Curves of rates of growth of science S(t), technology F(t) and industry Π(t).

Subsequent refinement and specification of the values of the weight factors for parameters (1) can be accomplished, based on taking account of the specific prognostic principles of growth in scientific-technical and economic progress. In the special literature [3, 13], a large number of methods of forecasting the factors of growth in scientific-technical and economic progress are introduced; some of these methods rest on a quite strong empirical or quite reliable or theoretical base. The majority of analytical methods of forecasting explicitly or implicitly are based on extrapolation of exponential or power principles of change in the primary characteristics of well-studied objects on the principal characteristics being studied of the field of phenomena being forecast. The basis for this type of extrapolation usually is the statistically determined empirical fact of exponential or S-shaped (logistical) nature of growth in time of many quantitative characteristics of growth of modern science, technology, industry and economics.

Therefore, in plotting the specific type of weight function $\eta(I)$, $\eta(Q)$ and $\eta(P)$ (see Fig. 3a), we used analytical methods in effect in practice of forecasting scientific, technical and economic output of research and development, reported, in particular, in [13]. Thus, /93 in plotting the weight function $\eta_i(J)$ for different values of I(in points), we proceeded from a prognostic estimate of the rates of increase in scientific information per unit time, which is based on the following empirically established principle of growth in scientific information (Fig. 2a):

$$J = \Gamma\left(1 - e^{-\frac{q\Omega_0}{c\Gamma}e^{ct}}\right). \tag{5}$$

where J is scientific information (the state of scientific knowledge); q is the mean productivity coefficient of one investigator per unit time; Ω_0 is the number of investigators actively engaged at moment of time t = 0; e is the natural logarithm base; c is a constant factor; Γ is the saturation limit (limiting volume (quantity) of new scientific information, which the investigators Ω_0 are capable of producing).

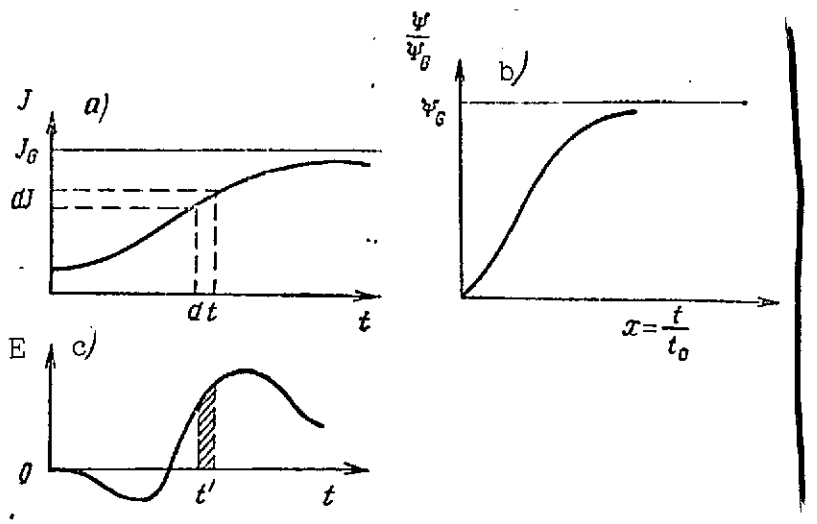

Fig. 2. Quantitative curves of growth of cognitive (a), technical(b) and economic (c) parameters of scientific research and development.

The plotting of the weight function η (Q) was based on the prognostic estimate of growth in the parameters of new technology, as a function of scientific-technical, financial and other resources expended on their development, which is based on the empirical principle of growth of scientific-technical parameters of the following type (Fig. 2b):

$$\frac{\psi}{\psi_0} = \theta \qquad \frac{1}{1-\theta}\frac{d\theta}{dx} = n x^{n-1}. \tag{6}$$

Here, is the ratio of the production of results of the scientific-technical parameter ψ, at given expenditures on development of it, to the maximum achievable results ψ_0, and $x = t/t_0$ is the ratio of the time expended in development of the scientific-technical parameter from the beginning of work to the present moment t, to the total time t_0 necessary for development of the parameter. A characteristic value $n = 2$.

In plotting the weight function $\eta(P)$, the prognostic estimate of the expected economic effect of a new scientific-technical development (project) was taken into account; it is based on the following empirically established relation (Fig. 2c):

$$e = \int_0^\infty x(t)\, e^{-rt}\, dt, \tag{7}$$

where e is the expected economic effect of the projected scientific-technical development, from the point of view of the present moment of time t, x(t) is a function characterizing the increase in benefit from the new development (project), and r is the standard of profit of the project.

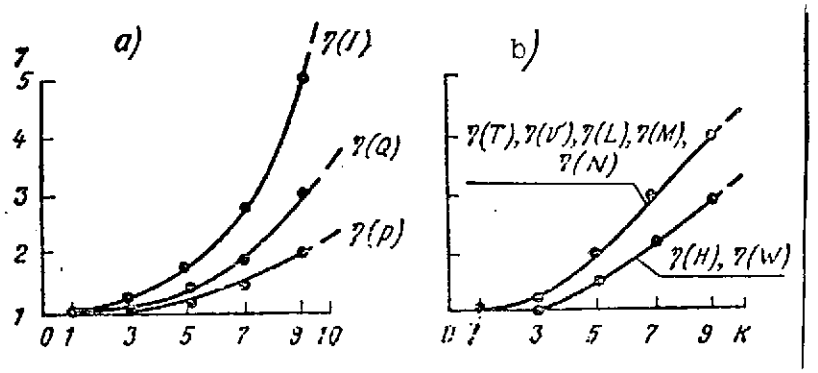

Fig. 3. Weight functionsfor indices of efficiency by subject area of scientific results (a), introduction of scientific results into practice and quality of the research process (b).

Specific numerical values of the weight factors η_i for the remaining parameters of equation (1) (Fig. 3b) were assigned, proceeding from the basis of evaluation of scientific research work (on a basis of experience in work of expert commissions on acceptance of completed work in scientific research subject areas, competition commissions of the scientific council of an institute, attestation commissions of a scientific research institute and the like), in effect in the work of the scientific research institute. We note that the overall relationships of the values of the weight factors for indices I, Q and P, characterizing the scientific, technical and methodological value of the results of the scientific research work, obtained on the basis of Table 2, correlate quite well with the statistical data on the relationships between the number of new scientific discoveries, inventions and proposals ofinnovators recorded annually in our country.

For convenience in monitoring and self-monitoring the efficiency of accomplishment in a scientific research subject area by R_Σ , all the basic parameters of (1) of a subject area, together with the corresponding quantitative point rating scales, can be reduced to a special chart,

an example of which is represented in Table 3. In this table-chart, the supervisor (expert) of the subject area represents the specific /94
numerical values (in points) of each index in the corresponding column of the ten-point scale by a +, based on the standard scale of parametric Table 1 and, in the columns K_i and η_i, the numerical values of the point rating and weight factor, respectively, determined expertly from Table 2. The total point rating of efficiency of accomplishment in a scientific research subject area $R\Sigma$ is found from computation of the simple arithmetic sum of the products $\eta_i K_i$ of equation (2) for all parameters.

We note in conclusion that the proposed system of standardized evaluation and monitoring of efficiency of scientific research work at all stages of accomplishment in a scientific research area obviously expresses one possible approach to solution of the urgent, but at the same time complicated and multiple, problem of increasing efficiency of research and development carried out in scientific institutions of the Hydrometeorological Service. Therefore, like any new development, this system needs further comprehensive checking, evaluation and testing in practice by the work of expert commissions of the Scientific Research Institutes, improvement and development.

CONCLUSIONS

1. The development of methods of evaluating the collective forms of scientific work is an important reserve for increasing efficiency of research and development of scientific research institutes. A system of correlated indices (parameters) of multiple efficiency of this work should be an organic component part of the operating plans and programs at all stages of accomplishment in scientific research subject areas, beginning with the stage of forecasting expected re- /96
sults and ending with the stage of providing summaries, converted in the hands of the supervisor and responsible worker in the subject area into an effective instrument for the timely prevention of costly errors and omissions in the work of scientific research institutes.

TABLE 3

CHART OF SUPERVISOR (EXPERT) OF SCIENTIFIC RESEARCH SUBJECT AREA

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Subject area _____

_____ Code _____

Subj.Supv. _____ Resp.workers _____

No. workers _____ Cost (1,000 rubles) _____ incl. pay _____

Stage _____ Calendar periods _____

Type of Indices	Name of correlated subject area index	Index	Rating (in points) 1	2	3	4	5	6	7	8	9	10	K_i	η_{ii}
Indices of results obtained by subject area	Scientific (theoretical, cognitive) value of results	I												
	Applied (experimental results	Q												
	Methodological value	P												
Level and scale of different forms of introduction of results by subject area	Level of scientific information (publ) introduction	L												
	Level of experimental-industrial introduction	M												
	Level of operational (network) introduction	N												
Indices of work performed in subject area (quality of research process)	Level of creative contribution	H												
	Level of technique and technology used in work	W												
	Planning level (quality)	T												
Level of importance of subject		U												
Total point rating	$R_\Sigma = \sum_{i}^{10} \eta_{ii} K_i$													

Note: The results of expert evaluation (in points) are noted for each generalized index in the appropriate places in the table by a + and, in columns K_i and η_{ii}, the specific numerical values for the corresponding indices I, Q, P, L, M, N, H, W, T, U

Supervisor (expert) of subject area:

2. For the system of efficiency indicators of scientific research work to acquire effective force and to become an operating portion of the operational plans and programs of the supervisors and workers in scientific research subject areas, it should be presented in standard form, i.e., in the form of a special nomenclature of a set of obligatory planned indicators of efficiency in accomplishment of scientific research work. Only in this favorable case, this system of indices is converted into an instrument of effective management of scientific research of an organized group at all stages of accomplishment in a subject area.

3. The specific analytical-parametric system and standards base for evaluation of efficiency of scientific research work presented in the article, developed on the basis of the principles of systematic analysis, permits accomplishing a simplified quantitative estimate of efficiency in accomplishment in scientific research areas of any type (scientific, scientific-technical or scientific-methodological nature), as well as to compare efficiency of accomplishment in different subject areas, by the total point rating.

4. To increase the accuracy of the quantitative estimates of efficiency of scientific research work on the basis of the total point rating, further improvement of the internal structure of the analytical-parametric system, standard tables of indices of efficiency of scientific research and the weight factors of these indices is necessary.

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